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Current Psychology Letters, 10, Vol.1, 2003 , Special Issue on Language Disorders and Reading Acquisition .

Article

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Résumé

Deux groupes d'enfants dyslexiques, caractérisés soit par un déficit phonologique (PH) soit par un déficit visuo-attentionnel (VA), ont été comparés à des groupes contrôles de même âge chronologique (CA) et de même âge de lecture (RA). Toutes les performances en lecture des deux groupes de dyslexiques sont inférieures à celles des contrôles CA et équivalentes à celles des contrôles RA. Le groupe dyslexique VA lit moins bien les mots irréguliers que le groupe dyslexique PH alors que la performance en lecture de pseudo-mots est aussi faible dans les deux groupes. Ces résultats vont à l'encontre de l'hypothèse de simple retard chez certains dyslexiques et remettent en cause les méthodes courantes d'identification de sous-types de dyslexie. Ils sont en accord avec le modèle multi-trace de lecture des mots polysyllabiques (Ans, Carbonnel & Valdois, 1998).

Abstract

The reading performance of two groups of dyslexic children with either a phonological (PH) or a visual-attentional (VA) deficit was compared to that of control groups matched on chronological age (CA) and reading age (RA). In both groups and on all the reading measures, the dyslexic children performed worse than the CA-controls but similarly to the RA-controls. Performance of the VA dyslexic participants in exception word reading was lower than that of the PH-dyslexics but the two dyslexic groups exhibited a similarly low performance in pseudo-word reading. These findings constitute arguments against the delay hypothesis and question the current methods used to identify dyslexia subtypes. They are in support of the multi-trace memory model of polysyllabic word reading (Ans, Carbonnel & Valdois, 1998).

Full Text

Implemented reading models contribute to a better understanding of developmental dyslexia in giving new insights on the cognitive deficits that might be responsible for this reading acquisition disorder.

The multi-trace memory model of polysyllabic word reading (Ans, Carbonnel & Valdois, 1998; ACV98 hereafter) postulates the existence of two reading procedures, a global and an analytic one, based on the same computational principles. The global procedure always proceeds first, the analytic procedure applying secondarily when global processing has failed. These procedures in particular differ by the size of the visual-attentional (VA) window through which information is extracted from the orthographic input. The VA window extends over the entire letter string when reading in global mode. During the first step of the analytic mode, the VA window is restricted to the first part of the orthographic sequence (typically a syllable). Then, the window moves to the second part and so on, until the word has been entirely processed. The phonological information generated at each step of analytic processing remains activated into a phonological buffer so that the entire phonological sequence is available at the end of processing. According to this model, two kinds of cognitive deficits can affect reading acquisition. First, a phonological deficit would disturb the elaboration of phonological outputs, in particular when words are processed in analytic mode. Second, an inability to extend the VA window over the whole sequence would prevent reading in global mode. The model therefore predicts that developmental dyslexia would result from two independent cognitive impairments, either a phonological or a VA processing deficit. Case studies have been conducted to demonstrate that VA disorders and phonological problems could dissociate in developmental dyslexia (Valdois, Bosse, Ans, Carbonnel, Zorman, David & Pellat, in press). In the present paper, two groups of dyslexic children with either a phonological or a VA deficit have been selected in order to determine the impact of these cognitive impairments on reading performance.

Method

Subjects

A large group of French dyslexic (N=68) and non-dyslexic children (N=86) was assessed on phonological and visual-attentional tasks (Bosse & Valdois, 2002). For the purpose of the present study, two groups of ten dyslexic children have been selected from this original sample. The PH-group gathered children exhibiting a phonological (PH) disorder but normal VA skills; Children in this group obtained the lowest scores of all the dyslexic children on at least two PH tasks but their scores on the VA tasks were within the normal range. Their mean age was 12 years 5 months (range: 9;7-15;2). Children in the VA-group demonstrated an isolated VA deficit ; they obtained the lowest scores of all the dyslexics on the VA tasks but normal PH scores (see Table 1). Their mean age was 11years 7 months (range: 9;1-14;7). The two groups have similar chronological ages ($t(18) = .92$, N.S.) but they differ in reading age (8 years 3 months and 7 years 3 months respectively, $t(18) = 2.6$, $p < .05$), as estimated with the "Alouette" reading test (Lefavrais, 1968). Four groups of ten control children matched on chronological age (PH-CA group, mean age: 12 years 1 month, range 9;9-13;2. VA-CA group, mean age: 11 years 6 months, range 9;0-12;10) or reading age (PH-RA group, mean age: 8 years 4 months, range: 7;6-10;0. VA-RA group, mean age: 8 years, range 7;3-9;7) with the phonological and VA experimental groups were further selected.

Material

Phonological tasks

The participants were submitted to 4 phonological tasks. In each task, 4 words were given as practice items. No feedback was provided on the experimental items.

Phonemic segmentation task (SEGM): The participants had to successively pronounce each of the constitutive phonemes of a word previously uttered by the experimenter (e.g., /fuR/ *oven* /f/ /u / /R/). The words (N=20) were made up of 4.2 phonemes on average (range: 3-6).

Phoneme deletion task (DELE): the participants were asked to delete the first sound of a word and produce the resulting pseudo-word (e.g., /plakaR/ *cupboard* /lakaR/). The words (N=20) began with either a vocalic phoneme corresponding to a digraph, a consonantal cluster or a singleton.

Acronym task (ACRO): children had to extract the first phoneme of 3 words successively pronounced by the experimenter (one per second), and recombine them to produce a new word. For example, they heard "/kan/ - /ubli/ -/dãs/" (*duck*, *forgetting*, *dance*) and had to say /kud/ *elbow*. The test comprised 15 series of 3 words made up of 3 phonemes on average (range 2 - 5).

Sound categorisation task (CATE): Children had to retrieve the odd word among 4 orally pronounced words (e.g., / tõ/ in "/vã/ - /bã/ - /tõ/ - /rã /" *wind* - *bench* - *tuna* - *row*). Twenty series of words, sharing either their initial, medial or final phoneme, were given.

Visual-attentional tasks

A bar probe task (Averbach & Sperling, 1968) was presented under two conditions of whole and partial report.

1)Whole report condition (WHOL): On each trial, the participants were required to orally report a string of 5 letters briefly presented at the centre of the monitor screen. The 20 random 5-letter strings (e.g., R H S D M) were built up from 10 consonants, used 10 times each and appearing twice in each position over the all trials. The letters were presented in upper-case (Geneva 24), spaced by one centimetre. The array subtended an angle of approximately 5.4°.

Procedure : At the start of each trial, a central fixation point was presented for 1000ms followed by a blank screen for 500ms. A centred letter string was then presented for 200ms. The participants had to report verbally all letters immediately after they disappeared. The task began with 5 training trials followed by the 20 test trials. The score was the number of letters correctly reported across trials (max = 100).

2)Partial report condition (PART): The task was similar to the previous one but a vertical bar appeared under one letter of the string immediately at the offset of the stimulus array. The participants had only to report the letter indicated by the probe.

Stimuli: fifty random 5-letter strings (e.g., T H F R D) were built up from the same 10 consonants as previously. The occurrence of each letter was 25 and each appeared five times in each position of the string. Each letter was used as target once in each position.

Procedure: At the offset of the 5-letter string, the bar probe appeared for 50 ms, 1 cm below the letter to be reported. Participants had to report the cued letter only. Ten training trials were presented first followed by the 50 experimental trials. The score was the number of target letters correctly reported (max = 50).

Reading tasks

The children had to read two lists of 20 exception words (EXW) and 20 consistent words (COW) matched in length and frequency. Each list was printed in column on a single sheet, in lower-case letters (Times, 14-point). Children were asked to read each list as quickly and accurately as possible. Accuracy of response was recorded together with reading time for the entire list. Reading speed (WRSpeed) was estimated as the mean reading time per word.

The dyslexic participants were further submitted to a list of 90 pseudo-words (PW) of 1-to-3 syllables constructed from 90 consistent words by substituting some of their letters (e.g., fracture froctare). The pseudo-words were presented in the same conditions as the words. The control participants read a reduced list of only 40 pseudo-words having the same characteristics as the extended list. Children were instructed that the items were invented words, and were asked to read them aloud as quickly and accurately as possible. The dyslexic PW scores were transformed as a ratio calculated on 40. Pseudo-word reading speed (PWRSpeed) was estimated per item, as for words.

Procedure: Each participant was tested individually in one or two sessions that were on average 8 days apart. The tasks were given in a random order.

Results

Performance of the dyslexic participants was first compared to that of the CA and RA controls. Then, results of the two dyslexic groups were directly compared.

As shown in Table 1, the performance of the PH dyslexics was significantly lower than that of the CA controls on all the phonological tasks (segmentation: $t(18) = -2.5$, $p < .05$; deletion: $t(18) = -4.3$, $p < .001$; categorisation and acronym: $t(18) = -3.8$, $p < .01$). Their mean performance was even lower than that of the RA participants but the difference was significant for the deletion task only ($t(18) = -2.8$, $p < .05$) and was near significance for categorisation ($t(18) = -2$, $p < .06$). In contrast, the PH dyslexic performance did not differ from that of the CA controls on the VA tasks (whole report: $t(18) = -1.8$, NS; partial report: $t(18) = .9$, NS). The VA dyslexic participants showed the opposite profile. They succeeded on all the phonological tasks (none of the comparisons with the CA controls are significant: $t(18) = 1.8$, 0, -1.8 and .3, all NS), but obtained abnormally low scores on the VA tasks. Not only they performed lower than the CA participants on the whole report ($t(18) = -7.5$, $p < .001$) and partial report ($t(18) = -10.1$, $p < .001$) tasks but their performance was even lower than that of the RA controls on both tasks ($t(18) = -3.3$ and -2.9, $p < .01$ and .05). Thus, one group of dyslexic children exhibits a single PH disorder whereas the other has a single VA deficit. Importantly, their performance cannot be considered as simply delayed, since impairment remains in the comparison with younger RA controls.

Table 1: Mean (SD) performance of the Dyslexic and Control Groups on the Phonological (SEGMentation, DELEtion, CATEgorisation and ACROnym) and visual-attentional Tasks (WHOLe and PARTial report).

	Group	SEGM	DELE	CATE	ACRO	WHOL	PART
PH	dyslexic	11.3 *** (3.9)	11.9 ** (3.5)	9.9 ** (3.7)	7.6 ** (4.4)	85.9 (6.6)	44.7 (2.9)
	CA	15.3 * (3.3)	17.7 *** (2.5)	15.8 ** (3.1)	13.2 ** (1.7)	91.1 (6.2)	43.5 (3.0)
	RA	13.5 (3.6)	16 * (3.0)	12.7 * (2.3)	10.5 (3.0)	82.6 (9.2)	39.5 (4.0)
VA	dyslexic	17.3 (2.5)	17.6 (3.2)	14.6 (1.9)	13.2 (1.0)	61.3 *** (9.7)	31.9 *** (3.6)
	CA	15.4 (2.1)	17.6 (2.4)	16.1 (1.9)	13 (1.2)	90.5 *** (7.5)	45.8 *** (2.4)
	RA	11.6 (2.5)	13.7 (3.7)	11.5 (2.5)	7.2 (3.4)	74 ** (7.2)	36.4 * (5.0)

* = p<.05; ** = p<.01 ; *** = p<.001

With respect to reading (cf. Table 2), performance of the PH dyslexic participants differed from that of the CA controls, both in accuracy (COW: $t(18) = -3.4$, $p < .01$; EXW and PW: $t(18) = -2.7$, $p < .05$) and reading speed (WRS: $t(16) = 4.1$ and PWRS: $t(16) = 5.3$, all $p < .001$). Comparisons with the RA participants revealed no significant difference on the reading measures.

Table 2: Mean (SD) performance of the Dyslexic and Control Groups on the reading measures (COnsistent Words, EXception Words and Pseudo-Words; Word and Pseudo-Word Reading Speed).

	Group	COW	EXW	PW	WRS speed	PWRS speed
PH	dyslexic	15.8 (3.8)	12.4 (5.0)	28.4 (6.4)	2.0 (1.1)	2.3 (0.8)
	CA	19.9 ** (.3)	17 * (2.1)	34.3 * (3.1)	0.6 *** (0.1)	0.9 *** (0.2)
	RA	16.2 (2.0)	9.1 (3.8)	30.2 (3.9)	1.5 (0.7)	1.7 (0.6)
VA	dyslexic	15.3 (3.2)	8.0 * (3.1)	28.8 (5.9)	2.5 (1.1)	3.3 (1.7)
	CA	19 ** (1.9)	16.4 *** (4.0)	33.1 (3.4)	0.7 *** (0.3)	1.0 *** (0.3)
	RA	15.8 (2.3)	6.3 (4.2)	29.1 (3.8)	1.9 (0.4)	2.2 (0.4)

*= p<.05; ** = p<.01 ; *** = p<.001

As compared to the CA controls, the VA dyslexic participants demonstrated significantly lower reading scores on words (COW: $t(18) = -3.2$, $p < .01$; EXW: $t(18) = -5.3$, $p < .001$) and low and near significance scores on pseudo-words ($t(18) = -2$, $p < .06$). Their reading speed was strongly slowed (WRS: $t(17) = 4.9$; PWRS: $t(17) = 4.2$, all $p < .001$). Comparisons with the RA controls revealed no significant difference on either reading scores or reading speed.

Direct comparison between the two dyslexic groups revealed that they differed significantly on their phonological (segmentation: $t(18) = -4.1$, $p < .001$; deletion: $t(18) = -3.8$, $p < .01$; categorisation: $t(18) = -3.6$, $p < .01$ and acronym: $t(18) = -3.9$, $p < .01$) and VA (whole report: $t(18) = 6.6$; partial report: $t(18) = 8.7$, all $p < .001$) scores. The VA dyslexics read exception words with less accuracy than the PH dyslexics ($t(18) = 2.4$, $p < .05$) but the two groups had similar scores on pseudo-words. In the same way, word and pseudo-word reading speed did not differ significantly in the two groups ($t(15) = -1$ and -1.4, all NS).

Discussion

In this study, the reading performance of two groups of dyslexic children who differed in their phonological and visual-attentional (VA) abilities was analysed. As compared to either the CA or RA controls, phonological skills were significantly lower in the PH group who otherwise exhibited normal VA processing skills. Reversely, the VA group demonstrated poor VA abilities despite very good phonological skills. It is noteworthy that despite their lower reading level, the VA dyslexics had higher phonological scores than the PH dyslexics. Finally, the poor performance of the two dyslexic groups on either the phonological or VA tasks cannot be interpreted as resulting from a delay in reading acquisition since they performed worse than the RA controls. The high phonological score of the VA dyslexic group is also a point against the hypothesis of a general delay which would result in poor performance on all the cognitive measures (Harm & Seidenberg, 1999). In sum, these two groups of dyslexic children exhibit different associated cognitive deficits: a selective phonological disorder characterises the PH group whereas a selective VA disorder characterises the VA group.

The two groups of dyslexic children differed from the CA controls by a lower performance in both reading accuracy and reading speed, whatever the nature of the item to be read. However, the dyslexic children performed similarly to RA controls on all the reading measures. These findings suggest that children with a specific cognitive disorder may have a reading performance similar to that of normally developing but younger children of the same reading age. Many authors have rejected the hypothesis of a specific cognitive disorder at the origin of developmental dyslexia on the basis of the similarity of performance between the dyslexic participants and younger controls of the same reading age (Manis, Seidenberg, Doi, McBride-Chang & Petersen, 1996; Stanovitch, Siegel & Gottardo, 1997; Genard, Mousty, Content, Alegria, Leybaert & Morais, 1998; Sprenger-Charolles, Colé, Lacert, & Serniclaes, 2000). The present study shows that dyslexic children with a specific and a priori identified cognitive disorder may nevertheless exhibit a reading performance comparable to that of younger controls. It follows that the similarity of reading performance between dyslexic and non-dyslexic but younger children cannot be taken as evidence against the hypothesis of a specific cognitive disorder underlying their reading impairment.

Comparison of the two dyslexic groups further revealed that the VA dyslexic participants had a lower performance in EXW reading than the PH dyslexics. It thus appears that a VA disorder has a greater impact on EXW reading than a PH problem, even if both disorders affect performance on exception words. However, both dyslexic groups showed low performance in PW reading, so demonstrating that pseudo-word reading impairment can result from either a phonological or a VA deficit.

Within the ACV98 framework, a reduction of the VA window would prevent the establishment of orthographic knowledge, thus leading to poor EXW reading abilities. However, in agreement with the self-learning hypothesis (Share, 1995, 1999), the ACV98 model further posits that analytic processing also contributes to the establishment of lexical knowledge. It follows that a PH disorder might slow down acquisition of lexical knowledge, thus resulting in a poor COW and EXW reading performance as compared to CA controls. However, EXW reading might be less disturbed following a PH than a VA disorder since the entire phonological form of words can be supplied by a supervisor during reading (e.g., when the teacher read) whereas poor analysis of the word orthographic sequence resulting from a VA disorder remains in condition of reading with a supervisor.

The existence of similar deficits in PW reading following either a PH or a VA disorder is may be a less intuitive result. The model predicts that a PH disorder would primarily disturb the analytic procedure, preferentially used for PW reading. However, simulations of acquired surface dyslexia conducted within the ACV98 network have shown that a severe reduction of the VA window had an impact on analytic processing as well. Probably that such a reduction would have still more dramatic consequences during reading acquisition. Indeed, a severe reduction of the VA window might prevent the extraction of graphemic or syllabic information during reading acquisition, therefore disturbing the establishment of knowledge required for analytic processing. Although further research is needed to simulate the impact of a VA window reduction on the establishment of the analytic procedure, previous findings (Valdois et al., in press) and the present data show that PW reading is impaired in children who exhibit a VA problem in the absence of any PH disorder. Such findings question the classical view that pseudo-word reading performance constitutes a pure measure of phonological skills. They rather suggest that a single symptom like poor pseudoword reading may reflect different cognitive impairments and can only be interpreted in light of converging evidence from a variety of PH and VA tasks.

Overall, the present results demonstrate that different cognitive deficits can result in a PW reading impairment or in an EXW reading impairment. They show that a selective cognitive disorder of the PH or VA skills does not necessarily found expression in a double dissociation between EXW and PW reading. They further demonstrate that dyslexic children with a specific cognitive impairment may have a performance similar to that of younger controls. Overall, such findings question the subtyping methods which identify dyslexic subgroups on the basis of the relative imbalances on EXW and PW reading and define abnormal patterns by comparison to the performance of a reading-level control group.

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To quote this article
Marie-Line Bosse and Sylviane Valdois . «Patterns of Developmental Dyslexia According to a Multi-Trace Memory Model of Reading». *Current Psychology Letters,* 10, Vol.1, 2003, Special Issue on Language Disorders and Reading Acquisition.
http://cpl.revues.org/document92.html